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Phenomenological Aspects of Gauge Mediation with Sequestered Supersymmetry Breaking in light of Dark Matter Detection

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Abstract

Recently, a model of gauge mediation with sequestered supersymmetry (SUSY) breaking was proposed. In this model, the mass of the gravitino is $\mathcal{O}(100)$ GeV without causing the flavor-changing neutral-current problem. In contrast to traditional gauge mediation, the gravitino is not the lightest SUSY particle, and the neutralino is the candidate of the dark matter. In this paper, we investigate phenomenological aspects of the model and discuss the possibility of the direct detection of the dark matter. In particular, we focus on the light neutralino case and find that the light-Higgsino scenario such as the focus point is interesting in the light of the recent CDMS result.

1 Introduction

The origin of the dark matter (DM) is one of the most challenging problems in particle physics and cosmology. In the framework of the minimal supersymmetric (SUSY) standard model (MSSM), the lightest SUSY particle (LSP) is a candidate of the DM, since it is stable due to the R-parity conservation. In the MSSM, the gravitino or the lightest neutralino, which is the mixed state of the Bino, neutral Wino and Higgsino, is appropriate for the DM candidate. Among them, the Bino-like neutralino DM is attractive. Its mass is predicted as $m_{\rm DM} \simeq \mathcal{O}(10-100)$ GeV to explain the present DM abundance. This mass scale is favorable for the discovery of the SUSY particles at the LHC. In addition, the Bino tends to be naturally lighter than the other SUSY particles because the $\mathrm{U}(1)_Y$ gauge interaction is weak.

In the framework of the gravity mediation scenario, the Bino DM can be naturally realized. However, the gravity mediation generally suffers from the serious flavor-changing neutral-current (FCNC) problem. Such a problem gives arise due to the flavor-violating non-renormalizable operators at the Planck scale. On the other hand, the gauge mediated SUSY breaking model (GMSB) [1] with $m_{3/2} \lesssim 1$ GeV is free from the FCNC problems. Then, the gravitino is the LSP, and the neutralino cannot be the DM.

In a recent work [2], two of the authors with F.Takahashi and T.T.Yanagida have shown that if the conformal sequestering occurs in the SUSY breaking sector, gauge mediation with $m_{3/2} = \mathcal{O}(100)$ GeV can be realized without conflicting with the FCNC problem (see also Ref. [3]). In this case, the Bino-like neutralino is the candidate of the DM. In this paper, we investigate the neutralino DM in GMSB model and discuss the detection possibility of the DM in the current and future experiments.

2 Gauge mediation with sequestered SUSY breaking

For the neutralino to be the LSP, the gravitino must be heavier than the neutralino, i.e. $m_{\tilde{\chi}_1^0} < m_{3/2}$. Then gravity mediation effects are generally non-negligible, which lead to the dangerous FCNC. The effects come from Planck suppressed operators in a Kähler

potential of the form

$$K \supset \sum_{i,j} \frac{C_{ij}}{M_{PL}^2} S^\dagger S \phi_i^\dagger \phi_j, \tag{1}$$

where S is a SUSY breaking chiral superfield in a hidden sector with $\langle S \rangle = F\theta^2$, ϕ_i the MSSM matter fields, $M_{PL} \simeq 2.4 \times 10^{18}$ GeV the reduced Planck mass, and C_{ij} some unknown constants which are supposed to be $\mathcal{O}(1)$. Here i, j are flavor indices. If C_{ij} is non-diagonal, those operators give a flavor-dependent mass matrix to the sfermions of order $m_{3/2}$.

In this section, we review the work of Ref. [2]. There, it was discussed that the neutralino becomes a possible candidate of the LSP in gauge mediation [1], by suppressing the operators (1) using the conformal sequestering mechanism [6, 7, 8, 9, 10, 11]. If the SUSY breaking hidden sector is near a conformal fixed point above the SUSY breaking scale, renormalization group (RG) effects make the operators (1) to become [2]

$$\sum_{i,j} \frac{C_{ij}}{M_{PL}^2} S^\dagger S \phi_i^\dagger \phi_j \to \left(\frac{\mu_R}{M_*}\right)^b \sum_{i,j} \frac{C_{ij}}{M_{PL}^2} S^\dagger S \phi_i^\dagger \phi_j, \tag{2}$$

where μ_R is a renormalization scale, M_* the scale at which the hidden sector flows near the conformal fixed point. The constant b is the minimum eigenvalue of the matrix $(\partial\beta_i/\partial g_j)$ evaluated at the fixed point, where g_i are coupling constants and β_i the beta functions of g_i. If the fixed point is infrared stable, we have $b > 0$. Therefore, the operators Eq. (1) are suppressed. This suppression continues until the conformal invariance breaks down, and the scale of breakdown is almost equal to the SUSY breaking scale $\mu_R \sim \sqrt{|F|}$ in the model of Refs. [8, 2]. In Fig. 1, we show the schematic of the model. After the suppression, the gravity mediation effects give a mass matrix to the sfermions of order

$$\begin{aligned} m_{\text{grav}}^2 &\sim C \left(\frac{\sqrt{M_{PL} m_{3/2}}}{M_*}\right)^b m_{3/2}^2 \\ &\sim (100 \text{ GeV})^2 \times C \left(10^{-8} \cdot \sqrt{\frac{m_{3/2}}{100 \text{ GeV}}} \cdot \frac{10^{18} \text{ GeV}}{M_*}\right)^b \left(\frac{m_{3/2}}{100 \text{ GeV}}\right)^2, \end{aligned} \tag{3}$$

[1] There are also hybrid models of gauge and gravity mediation with the neutralino DM. See e.g., Refs. [4, 5].

[2] We neglect operator mixings for simplicity.

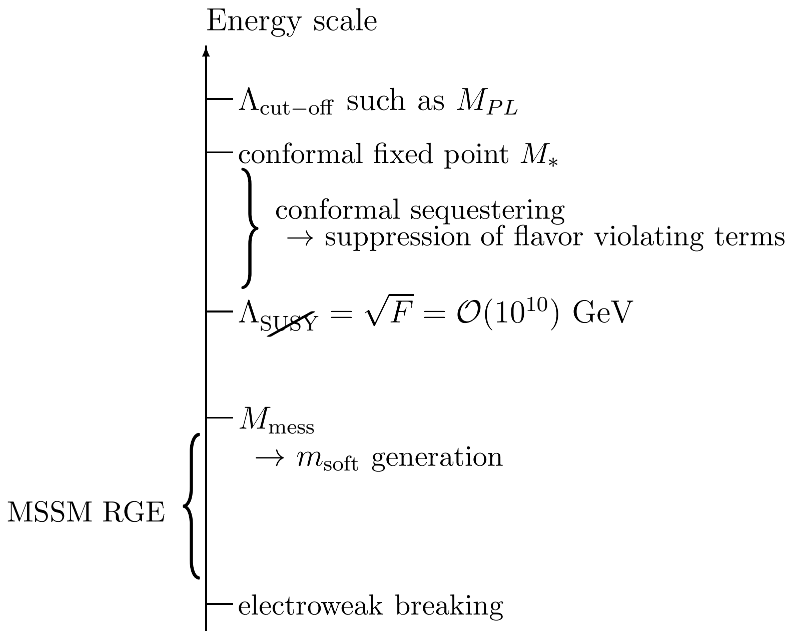


Figure 1: Schematic of our model

where C collectively denotes C_{ij}, and we have used $m_{3/2} = |F|/\sqrt{3}M_{PL}$. If M_* is sufficiently large, and b is $O(1)$ (i.e., the fixed point is strongly coupled), we can suppress the gravity mediation contributions. Assuming that $C \sim \mathcal{O}(1)$ and $m_{3/2} \sim \mathcal{O}(100)$ GeV, we require [12]

$$\epsilon \equiv \left(10^{-8} \cdot \sqrt{\frac{m_{3/2}}{100 \text{ GeV}}} \cdot \frac{10^{18} \text{ GeV}}{M_*}\right)^b \lesssim 10^{-4}, \tag{4}$$

to avoid the FCNC.

Gravity mediation contribution to the A-term is also suppressed. The A-term is generated, e.g., by the operator [3]

$$\int d^2\theta \sum \frac{C'_{ijk}}{M_{PL}} S\phi_i\phi_j\phi_k. \tag{5}$$

This term is suppressed to

$$\left(\frac{\sqrt{|F|}}{M_*}\right)^{\gamma_S/2} \int d^2\theta \sum \frac{C'_{ijk}}{M_{PL}} S\phi_i\phi_j\phi_k, \tag{6}$$

[3]The A-term is also produced by operators of the form $S^\dagger\phi^\dagger\phi/M_{PL} + \text{h.c.}$ in the Kähler potential, but the argument below applies with almost no change.

where γ_S is the anomalous dimension of S at the conformal fixed point. This gives the A-term of order

$$a_{ijk} \simeq 100 \text{ GeV} \times C'_{ijk} \left(10^{-8} \cdot \sqrt{\frac{m_{3/2}}{100 \text{ GeV}}} \cdot \frac{10^{18} \text{ GeV}}{M_*}\right)^{\gamma_S/2} \left(\frac{m_{3/2}}{100 \text{ GeV}}\right). \tag{7}$$

It is known that γ_S is positive from the unitarity bound of conformal field theory, and γ_S can be as large as $\gamma_S = 2$. Then, the suppression factor becomes as large as $\mathcal{O}(10^{-8})$ if $\gamma_S \simeq 2$ and $M_* \sim 10^{18}$ GeV. Thus, this term becomes negligible even if $C'_{ijk} \sim \mathcal{O}(1)$ (i.e. even without assuming that C'_{ijk} is proportional to the MSSM Yukawa couplings.)

There is another important effect in the conformal fixed point dynamics [2]. Let us consider a gauge mediation model with a superpotential

$$W = M\bar{\Psi}\Psi + yS\bar{\Psi}\Psi, \tag{8}$$

where Ψ and $\tilde{\Psi}$ are messenger fields. Due to the RG effect, the Yukawa coupling constant y becomes suppressed. Assuming that the messenger mass scale is smaller than the SUSY breaking scale $\sqrt{|F|}$, the Yukawa coupling at the messenger scale y_{mess} is related to the one at the scale M_*, y_0, as follows:

$$\begin{aligned} y_{\text{mess}} &\simeq y_0 \left(\frac{\sqrt{|F|}}{M_*}\right)^{\gamma_S/2} = y_0 \left(10^{-8} \cdot \sqrt{\frac{m_{3/2}}{100 \text{ GeV}}} \cdot \frac{10^{18} \text{ GeV}}{M_*}\right)^{\gamma_S/2} \\ &= y_0 \epsilon^{\frac{\gamma_S}{2b}}. \end{aligned} \tag{9}$$

Thus, the Yukawa coupling constant is naturally small. Actually, it is suppressed by $\epsilon^{\gamma_S/2b}$, at the messenger mass scale. This leads to a small messenger mass scale if we fix $\Lambda = yF/M$ and $m_{3/2} = F/\sqrt{3}M_{PL}$.

Lastly, let us touch on the μ problem in the model. In the gauge mediation, the problem is generally severe. However, it may be solved when the gravitino mass is $m_{3/2} \sim \mathcal{O}(100)$ GeV [2].

3 Dark matter and MSSM mass spectrum

Recently, CDMS collaboration reports two candidate events for the DM scatterings [24]. Although this number is too low to confirm the DM detection, compared with the expected

background event rate, they might be the first signal of the DM. Since the events have relatively low recoil energy, 11 and 15 keV, a light DM may be preferred, i.e. the DM mass does not far deviate from 100 GeV. Thus, we explore two cases in this section: the neutralino mass is above 100 GeV and smaller than it. At first, we consider the neutralino mass above 100 GeV. Here, we take account of the other phenomenological constraints, e.g. the LEP bounds on the particle masses and those from $b \to s\gamma$ and muon $g-2$. In the following analysis, we take the sign of the μ parameter to be positive. Secondary, we consider a lighter neutralino scenario, $m_{\tilde{\chi}_1^0} < 100$ GeV. This case may be particularly interesting, since the direct detection experiments are sensitive for light DM of the mass $30-60$ GeV. Thus, we will study the detection possibility of the light neutralino DM with the direct detection experiments.

3.1 Heavy neutralino

Firstly, let us discuss the heavy neutralino DM ($m_{\rm DM} \gtrsim 100$ GeV).

Minimal GMSB

We here consider a simple GMSB model, where a SUSY breaking field S couples to a pair of messenger chiral superfields, Ψ and $\bar{\Psi}$, which transform as $\mathbf{5}$ and $\bar{\mathbf{5}}$ under the $\mathrm{SU}(5)_{\rm GUT}$. The simplest form of the coupling of the messenger and the SUSY breaking field is

$$W = yS\Psi\bar{\Psi} + M\Psi\bar{\Psi}, \tag{10}$$

where M is the messenger mass, and y is set to be the value at the messenger mass scale throughout this section, i.e., $y = y_{\rm mess}$. In our model, y is naturally very small (see Eq. (9)). The SUSY breaking chiral field S develops an F-term vacuum expectation value (VEV) $\langle S \rangle = \theta^2 F$, which is related to the gravitino mass as $|F| = \sqrt{3} m_{3/2} M_{PL}$, assuming that the SUSY breaking is dominated by F.

In the GMSB models, the MSSM gaugino masses are generated from loop diagrams of the messengers. At the one-loop level, the gaugino masses are given by

$$M_a = \frac{\alpha_a}{4\pi}\Lambda_{eff}(1 + \mathcal{O}(x^2)), \tag{11}$$

where we have defined $\Lambda_{eff} = yF/M$ and $x = yF/M^2$. Here $a = 1, 2, 3$ labels U(1), SU(2) and SU(3) in the MSSM, respectively, and we use the normalization $\alpha_1 = 5\alpha_{\rm EM}/(3\cos^2\theta_W)$. The soft scalar masses arise at the two loop level, and are given by

$$m_{\phi_i}^2 \;=\; 2\Lambda_{eff}^2 \sum_a \left(\frac{\alpha_a}{4\pi}\right)^2 C_a(i)(1+\mathcal{O}(x^2)), \tag{12}$$

where $C_a(i)$ are Casimir invariants for the visible particles ϕ_i ($C_1(i) = 3Y_i^2/5$). x is bounded as $x < 1$ for the messengers not to become tachyonic, and then the corrections of $\mathcal{O}(x^2)$ are small and we omit these corrections in the following analysis. We see that $m_{\phi_i} \simeq M_a = \mathcal{O}(1)$ TeV is realized for $\Lambda_{eff} = \mathcal{O}(10^5)$ GeV.

Since the above expressions for the soft masses are given at the messenger scale, one should solve the MSSM RG equation to get the on-shell masses and mixing matrices.

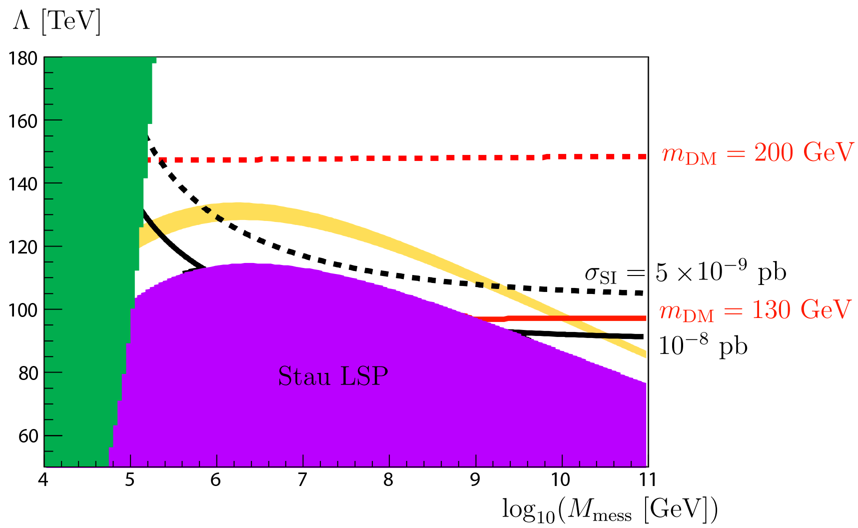
In Fig. 2-(a), we show the DM mass $m_{\rm DM}$, relic abundance Ωh^2 and spin-independent cross section to a nucleon $\sigma_{\rm SI}$, and in Fig. 2-(b), we show the Higgs mass m_{h^0}, the difference of the muon anomalous magnetic moment $\Delta a_\mu \equiv a_\mu|_{\rm MSSM} - a_\mu|_{\rm SM}$, and the difference of the branching fraction of $b \to s\gamma$, $\Delta{\rm Br}(b \to s\gamma) \equiv {\rm Br}(b \to s\gamma)|_{\rm MSSM} - {\rm Br}(b \to s\gamma)|_{\rm SM}$. Here, we set $\tan\beta = 40$. To calculate the MSSM mass spectrum and the DM property, we have used the programs `SOFTSUSY` 2.0.18 [13] and `micrOMEGAs` 2.2 [14]. $\Delta{\rm Br}(b \to s\gamma)$ is calculated with `SusyBSG` 1.3.1 [15]. As pointed out in Ref. [2], when $\tan\beta$ is large, the stau mass becomes smaller, and thus the coannihilation effect is essential for the correct DM abundance. Therefore the masses of the DM and sleptons are degenerate.

3.2 Light neutralino

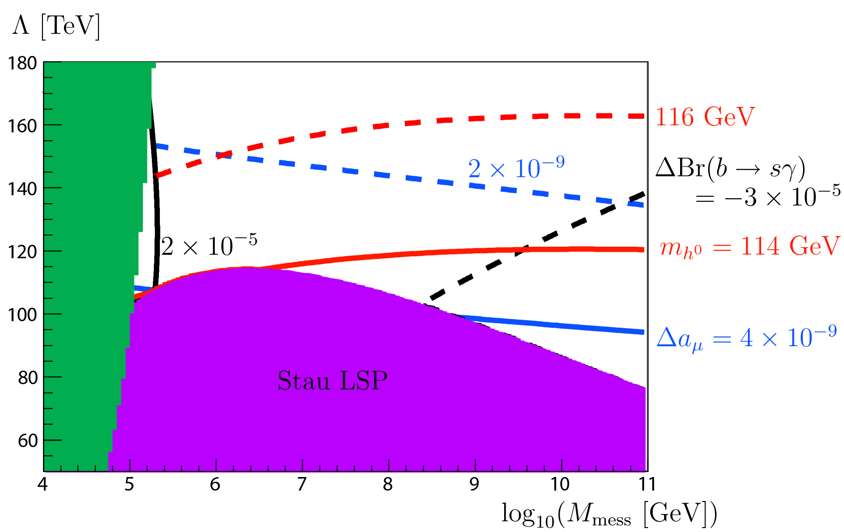
In this subsection, we study the case of the light DM, paying particular attention to the experimental constraints from collider and precision measurements.

Minimal GMSB

In Figs. 3, we show some parameters of the DM and MSSM spectrum with $\tan\beta = 10$. In the minimal GMSB, the Bino-like neutralino can be the LSP and the DM. However, if the mass of Bino-like neutralino is lighter than about 50 GeV, the lightest chargino is likely to be lighter than about 100 GeV, which conflicts with the current collider experiments. In Figs. 4, we show the masses of the lightest neutralino, chargino and stau. We also studied



(a)



(b)

Figure 2: (a): Red: DM mass $m_{\rm DM}$, Black: spin independent cross section to a nucleon $\sigma_{\rm SI}$. The yellow region shows $0.08 < \Omega h^2 < 0.12$. (b): Red: Higgs mass m_{h^0}, Blue: Δa_μ, Black $\Delta {\rm Br}(b \to s\gamma)$. In the green region, the messengers are tachyonic and in the purple region, the stau is the LSP.

the case that the representation of the messenger is $\mathbf{10} + \bar{\mathbf{10}}$. Here, we set $\tan\beta = 10$. One can see that, if the mass of the neutralino is $(30 - 50)$ GeV, some charged SUSY particles are too light to evade the LEP bound. In general, if the messenger belongs to a higher dimensional representation such as $\mathbf{24}$, the scalar particles tend to be lighter, and

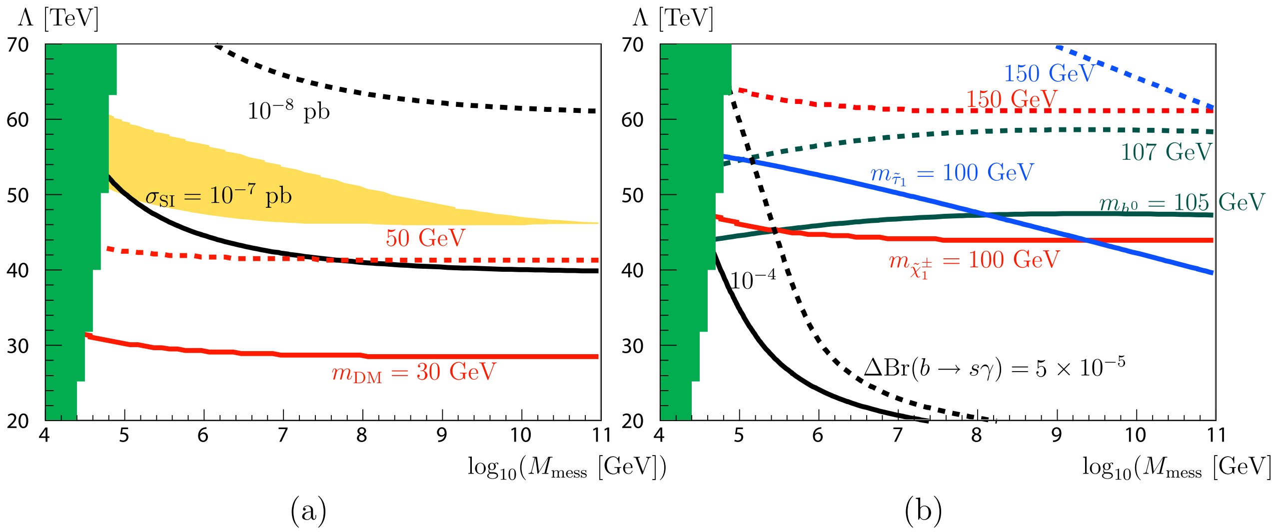


Figure 3: Some physical quantities in mGMSB with $\tan\beta = 10$. (a): red: DM mass, black: cross spin-independent section to a nucleon and yellow region shows $0.08 < \Omega h^2 < 0.12$. (b): red: $m_{\tilde{\chi}_1^\pm}$, black: $\Delta{\rm Br}(b \to s\gamma)$, green: Higgs mass m_{h^0}, blue: $m_{\tilde{\tau}_1}$. In the green region, the messengers are tachyonic.

the situation gets worse.

Non-minimal GMSB

Alternatively, we modify the coupling between the messenger and the SUSY breaking field as

$$W \;=\; \frac{\lambda}{M_P} S\Psi\langle\mathbf{24}\rangle\bar{\Psi} + M\Psi\bar{\Psi}, \tag{13}$$

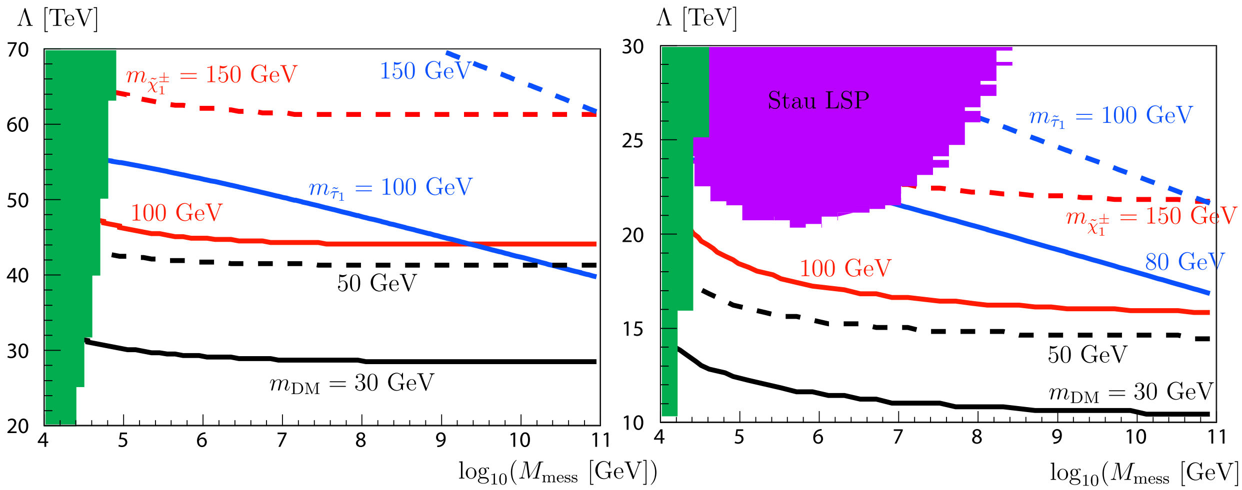
where $\langle\mathbf{24}\rangle$ is the VEV of an $SU(5)_{\rm GUT}$ adjoint field, which may be the GUT breaking Higgs field (a similar idea was used in Ref. [4]). By inserting $\langle\mathbf{24}\rangle = v\cdot{\rm diag}(3,3,-2,-2,-2)$, we have

$$W \;=\; y_\ell S\Psi_\ell\bar{\Psi}_\ell - \frac{2}{3} y_\ell S\Psi_d\bar{\Psi}_d + M(\Psi_d\bar{\Psi}_d + \Psi_\ell\bar{\Psi}_\ell), \tag{14}$$

where $y_\ell = 3\lambda v/M_P$. In this case, the down-type Ψ_d and lepton-type Ψ_ℓ messengers have the different couplings to the SUSY breaking field S.

The MSSM gaugino masses are given by

$$M_1 \;=\; \frac{\alpha_1}{4\pi}\frac{\Lambda_\ell}{3}, \tag{15}$$



(a) $\mathbf{5}+\bar{\mathbf{5}}$ (b) $\mathbf{10}+\bar{\mathbf{10}}$

Figure 4: Masses of the lightest neutralino, chargino and stau.

$$M_2 = \frac{\alpha_2}{4\pi}\Lambda_\ell, \tag{16}$$

$$M_3 = -\frac{\alpha_3}{4\pi}\frac{2\Lambda_\ell}{3}, \tag{17}$$

where $\Lambda_\ell = y_\ell F_S/M$. The soft scalar masses are given by

$$m_{\phi_i}^2 = 2\left(\frac{\alpha_1}{4\pi}\right)^2 C_1(i)\frac{7\Lambda_\ell^2}{9} + 2\left(\frac{\alpha_2}{4\pi}\right)^2 C_2(i)\Lambda_\ell^2 + 2\left(\frac{\alpha_3}{4\pi}\right)^2 C_3(i)\frac{4\Lambda_\ell^2}{9}. \tag{18}$$

In this case, $m_{\tilde{W}} \simeq 6m_{\tilde{B}}$. Thus, the lightest chargino can be heavy to evade the experimental bounds, even if $m_{\rm DM} \simeq 30$ GeV.

As an example, in Fig. 5 we show the MSSM mass spectrum at the point $M = 10^6$ GeV, $\Lambda_\ell = 110$ TeV, $\tan\beta = 10$ and $\mathrm{sgn}(\mu) = +1$.

In Figs. 6 and 7, we show some physical quantities as functions of Λ_ℓ and $M_{\rm mess}$. We set $\tan\beta = 10$ for Figs. 6 and $\tan\beta = 20$ for Figs. 7. In this case, the lightest neutralino has sizable components of the Higgsino for a small value of the messenger mass M. There are two reasons for that. One reason is that the colored SUSY particles are rather light in the non-mGMSB model (see Eqs. (18) and (12)). The other reason is that the running of the RG equation is short.

We notice that the sign of the gluino is negative, which is opposite to that of the Wino. This seems to be dangerous, because the SUSY contribution to the $b \to s\gamma$ ratio tends

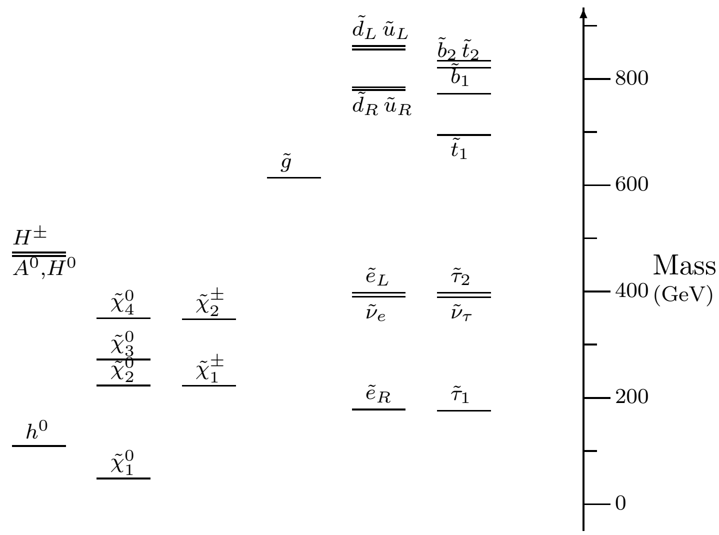
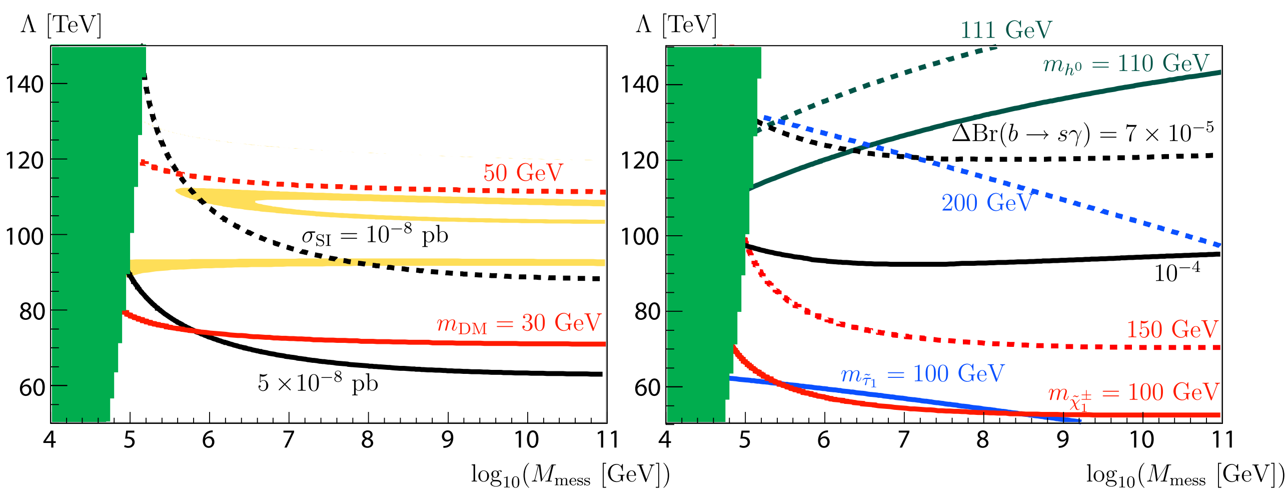


Figure 5: An example of the MSSM mass spectrum in the non-mGMSB model.

to be large. Since the squark masses are around 1 TeV, and the A-parameter of the top squark is suppressed, the $b \to s\gamma$ constraint is found to be ameliorated.

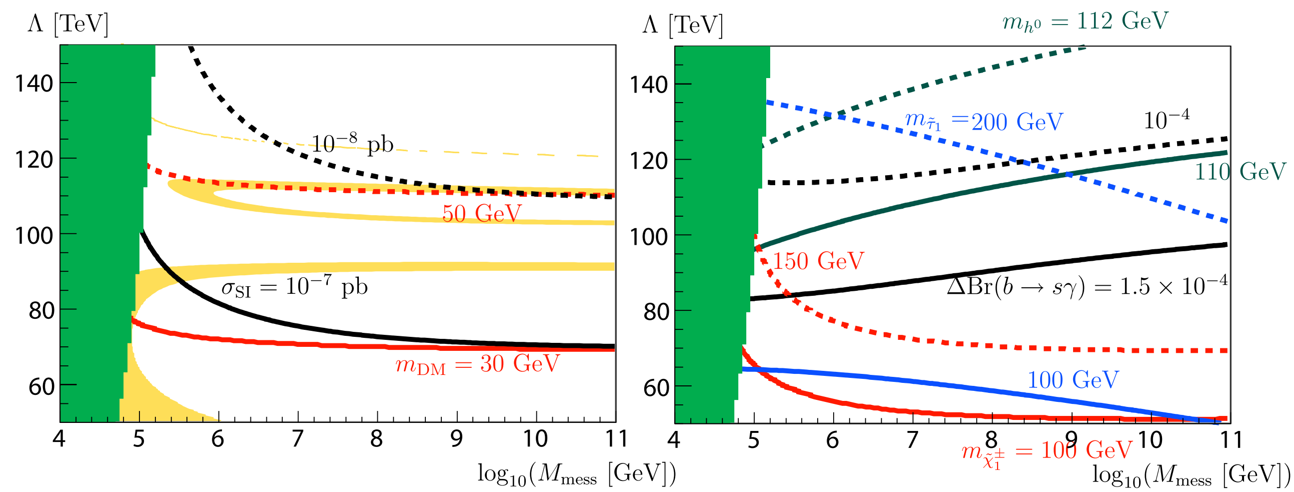


(a) (b)

Figure 6: Same as Figs. 3 except non-mGMSB with $\tan\beta = 10$.

4 Scan of parameter space

We scan over the parameter space of the model and discuss the detection possibility of the DM. We scan over Λ_{eff} or $\Lambda_\ell < 1500$ TeV, $M_{\rm mess} < 10^{11}$ GeV and $2.5 \leq \tan\beta \leq 50$



(a) (b)

Figure 7: Same as Figs. 3 except non-mGMSB with $\tan\beta = 20$.

and impose the following constraints:

- $m_h > 110$ GeV [16].[4]
- $m_{\tilde{\chi}_1^\pm} > 100$ GeV [17].
- $m_{\text{charged slepton}} > 100$ GeV [18].
- $-3 \times 10^{-5} < \Delta\text{Br}(b \to s\gamma) < 1.4 \times 10^{-4}$ [19, 20].
- $0 < \Delta a_\mu < 4 \times 10^{-9}$ [21] .
- $\Gamma(Z^0 \to \tilde{\chi}^0\tilde{\chi}^0) < 2$ MeV [22].
- $0.01 < \Omega h^2 < 0.2$ [23]. [5]
- Λ_{eff} or $\Lambda_\ell < M_{\text{mess}}$.

In Fig. 8, we show the allowed region as a function of the DM mass and spin-independent cross section. In the mGMSB, the correct DM abundance is achieved with the coanni-

[4]This is lower than the LEP bound $m_{h^0} > 114.4$ GeV, justified by uncertainties involved in the Higgs mass calculation.

[5] We have examined the finite number ($\sim 10^6$) of parameter points. If we impose the constraint from WMAP DM abundance strictly, only tiny number of events can survive, which is statistically insufficient for the parameter search. To enhance the number of parameter points which survive the constraints, we loosen the condition for the DM abundance. We expect that the allowed region in Fig. 8 does not change significantly even if we impose severer constraint on the DM abundance. This is because, in the region $\Omega h^2 \sim 0.1$, the DM abundance depends on the input parameters more strongly than other physical parameters.

hilation effects, and in the non-mGMSB, focus-point like and/or Z^0/h^0 pole effects play important role, for $m_{\rm DM} \lesssim 60$ GeV. As for $m_{\rm DM} \gtrsim 100$ GeV, there are two regions. One is the coannihilation region like mGMSB cases. The other is focus-point like region. The latter region has large $\sigma_{\rm SI}$. In the non-mGMSB cases, the colored SUSY particles have lower masses than the mGMSB ones (see Fig. 5). Therefore, the value of μ tends to be small, which causes large mixing of the Bino and Higgsino components.

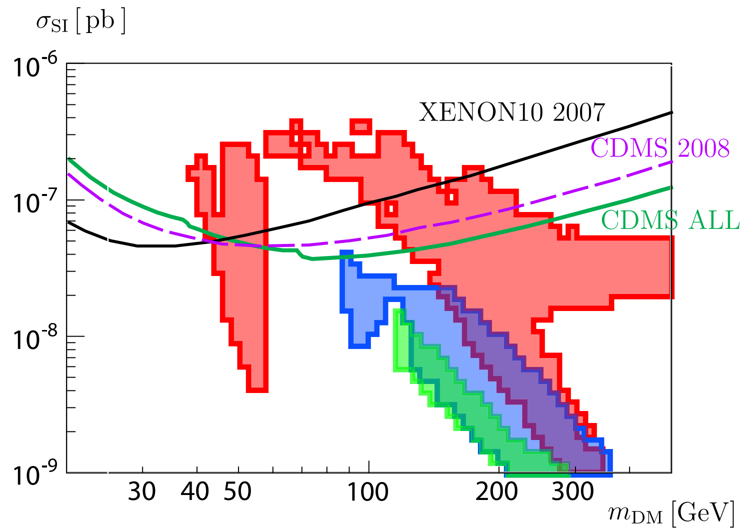


Figure 8: DM mass $m_{\rm DM}$ and spin-independent cross section $\sigma_{\rm SI}$ with experimental data [25, 26]. The red region shows non-mGMSB, blue mGMSB with $\mathbf{5} + \bar{\mathbf{5}}$ messenger and green mGMSB with $\mathbf{10} + \bar{\mathbf{10}}$ messenger.

5 Conclusion and discussion

In this paper, we investigated the phenomenological aspect of the GMSB with sequestered SUSY breaking. The model is attractive, because the neutralino is the candidate of the DM and is free from the serious FCNC problems. We especially studied the lighter DM scenario, taking into consideration the possibility of direct detection of the DM. Although the recent CDMS result is still too tenuous to confirm the DM detection, one cannot reject the possibility of the DM signals. Then, the CDMS result may prefer the lighter DM. If the light DM with $m_{\rm DM} \lesssim 100$ GeV is measured in future experiments, minimal type GMSB is implausible, since the cross section to a nucleon of the DM is small, and

the charged SUSY particles tend to be light, which conflict with the LEP bound. In this paper, we discussed a modification of mGMSB to evade the current experimental bounds.

In more general gauge mediation models, it is known that the masses of the three gauginos $\tilde{g}$, $\tilde{W}$ and $\tilde{B}$ can be completely independent. In Ref. [27] it was shown that gauge mediation models in general can be parametrized by six parameters, Λ_{Ga} and Λ_{Sa}^2 ($a = 1, 2, 3$), by which the gaugino and sfermion masses are given by

$$M_a = \frac{\alpha_a}{4\pi}\Lambda_{Ga} \quad (a = 1, 2, 3), \tag{19}$$

and

$$m_{\phi_i}^2 = 2\left(\frac{\alpha_1}{4\pi}\right)^2 C_1(i)\Lambda_{S1}^2 + 2\left(\frac{\alpha_2}{4\pi}\right)^2 C_2(i)\Lambda_{S2}^2 + 2\left(\frac{\alpha_3}{4\pi}\right)^2 C_3(i)\Lambda_{S3}^2. \tag{20}$$

It was shown that all the parameter space is realizable [28, 29] by constructing toy messenger models. Notice that the above formulae in particular show that the three gaugino masses are completely free parameters in general. In this general framework, it is easy to evade the experimental bounds. Although the parameter space is quite huge to investigate, the essence of the light neutralino DM seems to be common. It is expected that sizable mixing of the Bino and Higgsino and possibly Higgs or Z^0 pole effects are important. In this case, the third family quark jets are expected to be characteristic signals just like a focus-point in the gravity mediation [30, 31, 32, 33], if the gluino is relatively light, compared to the masses of the squarks.

The future XENON100 experiment will reach $\sigma_{\rm SI} \sim 2 \times 10^{-9}$ pb. In this sensitivity, much of the parameter space with $m_{\rm DM} \lesssim \mathcal{O}(100)$ GeV can be covered.

Note added: while this work was being completed, Ref. [34] appeared. They also studied neutralino DM models in gauge mediation, paying attention to the FCNC problems.

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